Yaldhurst Air Quality Monitoring

22 January – 21 February 2018

Report 2

20 March 2018

Prepared for

Environment Canterbury

by Paul Baynham

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Yaldhurst Air Quality Monitoring 22 January – 21 February 2018

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Client: Environment Canterbury

Prepared by:

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Revision History

No.	Date	Author(s)	Reviewer(s)	Details
1	14 Mar 2018	**Paul Baynham** Senior Air Quality Specialist (Mote)	**Brett Wells** Managing Director (Mote) **Louise Wickham** Director & Senior Air Quality Specialist (EIL)	Draft report to client for comment
2.2	20 Mar 2018	As above		Final report (Minor technical corrections)

Executive summary

In November 2017, Environment Canterbury contracted Mote Ltd to undertake ambient air quality monitoring for three months around the Yaldhurst quarries. Installation and commissioning commenced in December 2017 with the first month monitoring report (for the period 22 December 2017 – 21 January 2018) provided on 1 February 2018. This is the second report, which covers the period from 22 January 2018 through to 21 February 2018.

Mote undertook ambient air quality monitoring at six locations in the vicinity of quarries in the Yaldhurst area, west of Christchurch. The monitoring stations consisted of nine continuous PM_{10} and three continuous $PM_{2.5}$ nephelometers for measurement of hourly dust nuisance. Each of the six monitoring sites also employed a respirable crystalline silica (RCS) monitor which operated for a full month. Two sites further employed beta attenuation monitors (BAM – a reference method) for reference measurement of PM_{10} as a 24-hour average.

There were three exceedances of the Ministry for the Environment hourly suggested trigger threshold for dust nuisance (150 $\mu g/m^3$) at two sites south of the quarry:

- Site 5 South (west) rural – 173 $\mu g/m^3$ at 11:00 am – 12:00 pm on 1 February 2018;
- Site 5 South (west) rural – 205 $\mu g/m^3$ at 12:00 – 1:00 pm on 1 February 2018; and
- Site 3 South (east) rural – 284 $\mu g/m^3$ at 12:00 – 1:00 pm on 1 February 2018.

These exceedances coincided with a strong north-westerly wind change and dust complaints to Environment Canterbury.

There were no exceedances of the national environmental standard for PM_{10} as a 24-hour average during this reporting period.

In addition to the above, on 9 February 2018 Mote installed and commissioned transect PM_{10} nephelometers at four locations downwind of a quarry. These monitors were installed to assess dust attenuation during north-westerly wind events. Since the date of installation, no such wind events have been recorded yet.

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1.0 Background

In November 2017, Environment Canterbury contracted Mote Ltd to undertake ambient air quality monitoring for three months around the Yaldhurst quarries. Installation and commissioning commenced in December 2017 with the first month monitoring report (for the period 22 December 2017 – 21 January 2018) provided on 1 February 2018. This is the second report, which covers the period from 22 January 2018 through to 21 February 2018.

The background and terms of reference of this monitoring project are detailed in the first month report (Mote, 2017).[1]

1.1 Monitoring locations

To respect resident's privacy, this report will not disclose the exact locations of monitoring equipment on residents' private property. Their general locations may be typified as:

- **Site 1: East** - rural/residential location a few hundred metres to the east of the quarries
- **Site 2: North (east)** - rural/residential location a few hundred metres to the north of the quarries
- **Site 3: South (east)** – rural location a few hundred metres in the prevailing wind direction to the south east of the quarries
- **Site 4: Background** - background (rural/residential) location
- **Site 5: South (west)** - rural location a few hundred metres to the south west of the quarries
- **Site 6: North (west)** - rural/residential location a few hundred metres to the north of the quarries
- **Site 7**: **Transect 1** – rural location 250 metres south of quarries
- **Site 8: Transect 2** – rural location 500 metres south of quarries
- **Site 9: Transect 3** – rural location 650 metres south of quarries

The sites general locations are in **Figure 1**.

Table 1 presents a summary of monitoring undertaken around the Yaldhurst quarries for the period 22 January 2018 – 21 February 2018.

[1] Mote & Emission Impossible Ltd, 2017. *Yaldhurst Air Quality Monitoring*. 22 December 2017 – 21 January 2018. Prepared for Environment Canterbury. 9 Feb 2018.

Figure 1 Indicative (only) locations of monitoring sites

Table 1 Summary Yaldhurst Air Quality Monitoring: Jan – Feb 2018

Site	Location	Type	Monitoring
1	East	Rural/residential	Nephelometer PM_{10}
2	North (east)	Rural/residential	Nephelometer PM_{10} BAM PM_{10} Nephelometer $PM_{2.5}$ Meteorology
3	South (east)	Rural	Nephelometer PM_{10} Nephelometer $PM_{2.5}$
4	Background	Rural/residential	Nephelometer PM_{10} BAM PM_{10} Nephelometer $PM_{2.5}$
5	South (west)	Rural	Nephelometer PM_{10}
6	North (west)	Rural/residential	Nephelometer PM_{10}
7	Transect 1	Rural 250m south of quarries	Nephelometer PM_{10}
8	Transect 2	Rural 500m south of quarries	Nephelometer PM_{10}
9	Transect 3	Rural 650m south of quarries	Nephelometer PM_{10}

1.2 Monitoring methods

Nephelometer monitoring

An air quality nephelometer is an optical sensor that uses light scattering from particulate matter to provide a continuous real-time measurement of airborne particle mass. The light source is a visible laser diode and scattered light is measured in the near forward angle using focusing optics and a photo diode. The nephelometer has an on-board temperature sensor, which corrects for thermal drift, sheath air filter to keep the optics clean, automatic baseline drift correction and a fibre optic span system to provide a check of the optical components.

The near-forward nephelometers used in this study are more accurate that comparable side scattering nephelometers. However, as the near-forward scattering is less sensitive to particle size, they require a particle size inlet or sharp cut cyclone to provide a mechanical means of separating the size fraction prior to measurement. For this study, we have deployed a PM_{10} sharp-cut cyclone co-located with each nephelometer. We have also included a $PM_{2.5}$ sharp cut cyclone with an additional nephelometer at three sites (Sites 2, 3 and 4).

Our nephelometers take a reading once per second, we use a small single board computer to record these readings and calculate the average concentration each minute. The same single board computer uses a GPS to determine the local time very accurately – this way we can time stamp the data. Every 10 minutes, we transmit the previous data to our server using a cellular modem. We take

the data and plot this on our website. Interested persons can access this data through a secure web-portal.

We have installed the nephelometers on poles and tripods at heights of between 1.5 and 2 metres above ground level. Excepting Site 2 and Site 4 (which are connected to mains power), the remainder of nephelometers are powered using a 12 volt battery which itself is charged using solar panels. To assist with smooth site operation and data interpretation, we have mounted ultrasonic wind sensors on poles alongside the nephelometers.

The nephelometer utilises a heating control system based on relative humidity concentrations. When the relative humidity exceeds the set point (30% RH), the inlet heater switches on. This reduces the relative humidity down to below the set point at which point the heater switches off.

NB: Nephelometers are not reference instruments. This means we cannot directly compare PM_{10} data from nephelometers with the 24-hour average national PM_{10} standard. (For this reason, we have also co-located a Beta Attenuation Monitor (BAM) at Sites 2 and 4. PM_{10} data from a BAM can be directly compared with the 24-hour average national PM_{10} standard).

Figure 2, which follows, illustrates the types of nephelometers we have deployed around the Yaldhurst quarries.

Figure 2 Typical nephelometer installations. The unit on the left is mains powered, while the unit in the centre is battery powered. The unit on the right provides a close up.

Beta Attenuation Monitoring

A Beta Attenuation Monitor or BAM is a widely used air monitoring technique employing the absorption of beta radiation by solid particles extracted from airflow. We are using Thermo FH62 C14 beta attenuation monitors inside temperature-controlled enclosures. These are located at Site 2 (to the north of the quarries) and Site 4 (background site).

We operate the FH62 BAM in accordance with the *Good Practice Guide for Air Quality Monitoring and Data Management* (MfE, 2009) and in accordance with the standard method specified in the Resource Management (National Environmental Standards for Air Quality) Regulations 2004:

Australian/New Zealand Standard AS/NZS 3580.9.11:2008, Methods for sampling and analysis of ambient air—Determination of suspended particulate matter—PM_{10} beta attenuation monitors

Due to the power requirements of both the instrument and the temperature-controlled enclosure, both sites operate using mains power.

Figure 3, which follows, shows a typical BAM installation.

Figure 3 An example of a temperature controlled BAM enclosure with the doors open to illustrate the BAM inside

Respirable Crystalline Silica (RCS)

In addition to the PM_{10} nephelometers, respirable crystalline silica monitors were deployed at each of the six sites. Each monitor consists of a pre-weighed PVC filter housed within a polycarbonate cassette. Air is sampled at a rate of 2.5 litres per minute through an aluminium cyclone. The cyclone removes particles larger than 4 µm in diameter. The air flow itself is measured using a flow sensor connected to a flow controller. This ensures that the flow through the cyclone is maintained at 2.5 litres per minute throughout the sampling period. The aluminium cyclone is heated by 10 degrees above the ambient air temperature to remove water droplets from the sample air.

The purpose of this sampling is to collect sufficient monthly respirable crystalline silica (RCS) samples to enable comparison with suitable international guidelines.

1.3 Data validation

We undertook data quality assurance and validation in accordance with good practice (MfE, 2009). In summary, this involves:

- Data review to ensure no drift or baseline shift
- Examination of check and calibration records
- Removing data collected during calibration and maintenance, including sufficient time for instrument stabilisation
- Removing negative values (except where data within system uncertainty)
- Removing spurious positive/negative spikes[2]

There will inevitably be differences between (raw, un-validated) data reported online and the data in this report. Some of these arise as a result of differences from data validation, as discussed above, and some are structural.

Structural differences arise from differences in the way the data are reported. For example, **Figure 4** provides a screenshot of nephelometer PM_{10} data from Site 1 for the month of January 2018.

[2] NB: Occasionally, large negative spikes may occur due to instrumental error. These negative (and positive) spikes are reviewed during the data analysis process to evaluate whether they are real or spurious. Unless there is good evidence to remove a value, they are left in and a comment made in the metadata (MfE, 2009).

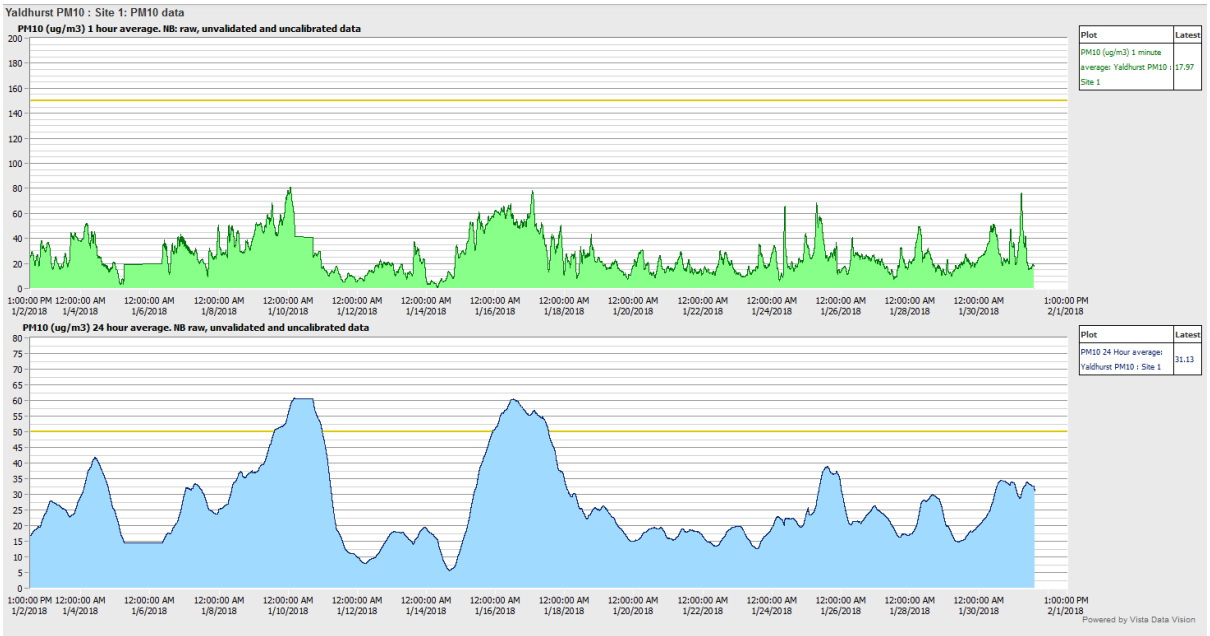

Figure 4 Screenshot of online nephelometer PM_{10} data for Site 1: East rural/residential 1:00 PM 2 Jan 2018 – 3:00 PM 31 Jan 2018

The top graph in **Figure 4** is hourly PM_{10}, and the hourly averages are updated each minute, hence the data have a spiky appearance. This will look different to the hourly data shown in **Figure 5**, which is updated once an hour and has a slightly smoother appearance.

Similarly, the daily PM_{10} averages in the bottom graph in **Figure 4** are updated every hour, each and every day. The rolling 24-hour average is thus a smooth line and looks very different to the bar chart in **Figure 6**, which presents true daily averages for each day (i.e. the full 24-hours of each day commencing at midnight, continuing through the early hours of the morning, noon and finishing at midnight that night).

Being raw, the data also include measurements during calibration and maintenance as well as site outages. Details of events that may impact the monitoring data are discussed in Section 2.0.

1.4 Frequently Asked Questions

What is an exceedance?

When we measure a concentration on our instruments around Yaldhurst that is higher than assessment criteria, we refer to this as an “exceedance”.

The concentrations are measurements taken and averaged over the relevant time period (i.e. one hour or 24 hour averages). Each of the nephelometers used in this study makes a reading every second, we average these readings to produce one minute concentrations. We then use these 1 minute concentrations to plot the 1 hour average and 24 hour average graphs (which can be seen on our website).

To calculate an average 1 hour concentration we add each minute of data between the start of the hour and the end of the hour and divide this by the number of minutes of data (e.g. 60 minutes).

The ongoing monitoring data generate running or continual 1 hour average and 24 hour average plots. For reporting purposes, we calculate a separate 1 hour average for each hour of the day and then average these 1 hour averages for each 24 hour day (starting at one minute past midnight and finishing at midnight).

What is the suggested PM_{10} trigger threshold for dust nuisance?

In 2016, the Ministry for the Environment published a document titled "Good practice guide for assessing and managing dust" (MfE, 2016). This document includes a section on setting trigger levels for proactive on-site dust management and suggests a dust nuisance trigger level of 150 µg/m^3 as a 1-hour average.

NOTE: while we have adopted the Ministry's suggested trigger threshold of 150 µg/m^3 it is important to note that there are site specific factors which mean that an appropriate trigger level could be higher or lower (to indicate actual dust nuisance). For more information on this, please refer to the good practice guide for assessing and managing dust on the Ministry for the Environment website.

Why do the 24 hour PM_{10} website graphs sometimes show values above the national environmental standard and why are these not reported as 'exceedances'?

The data for the website PM_{10} graphs comes from nephelometers. While these instruments are very useful for identifying short term issues over minutes or hours, they are not as accurate as (more expensive) reference instruments for comparing against longer term standards such as the 24 hour national environmental standard for PM_{10}.

The regulations relating to the PM_{10} national environmental standard mandate that only reference instruments may be used (for direct comparison with this standard). We are operating two reference instruments (beta-attenuation monitors or BAM's) around Yaldhurst.

2.0 Results

The first month monitoring report detailed instrument installation and commissioning. In this (second) month we deployed transect monitors 1, 2 and 3 as detailed in Section 2.8 below.

Please note that time averages are retrospective. Thus, we report data collected between 2:00 PM and 3:00 PM as an hourly average for 3:00 PM. Similarly, a 24-hour average for Monday 25 December is for the full 24-hours of Monday commencing at (1 minute after) midnight Sunday 24 December and finishing at midnight on Monday 25 December.

NB: As noted above in Section 1.2, we cannot compare nephelometer PM_{10} data directly with the 24-hour average national PM_{10} standard. This is because nephelometer PM_{10} data are indicative only (for indicating dust nuisance and investigating spatial and temporal resolution). However, we can (and do) compare PM_{10} data measured by the beta attenuation monitor (BAM) directly with the 24-hour average national PM_{10} standard. BAMs are deployed at Site 2 (North) and Site 4 (Background).

Table 2 presents the data capture and per cent valid data obtained at each site during the monitoring period 22 January – 21 February 2018.

Table 2 Per cent valid monitoring data 22 Jan – 21 Feb 2018

Site	Monitoring	% Valid Data[1]	Comments
1	Nephelometer PM_{10}	99.9%	Tampering of instrument on 31 January. 61 minutes of suspect data removed.
2	Nephelometer PM_{10}	96.7%	Power outage resulted in 1453 minutes of lost data on 1st and 2nd of February
	BAM PM_{10}	96.2%	Power outage resulted in 1503 minutes of lost data on 1st and 2nd of February. The BAM takes time to warm-up after a power outage, which is why more data was invalidated for this instrument than for the adjacent nephelometers.
	Nephelometer $PM_{2.5}$	96.7%	Power outage resulted in 1453 minutes of lost data on 1st and 2nd of February
	Meteorology	96.7%	Power outage resulted in 1453 minutes of lost data on 1st and 2nd of February
3	Nephelometer PM_{10}	100%	
	Nephelometer $PM_{2.5}$	100%	
4	Nephelometer PM_{10}	100%	

Site	Monitoring	% Valid Data[1]	Comments
	BAM PM_{10}	99.4%	Daily calibration data removed
	Nephelometer $PM_{2.5}$	100%	
5	Nephelometer PM_{10}	100%	
6	Nephelometer PM_{10}	100%	
7	Nephelometer PM_{10}	100%	
8	Nephelometer PM_{10}	100%	
9	Nephelometer PM_{10}	100%	

Notes

[1] Calculated on hourly average data

2.1 Site 1: East rural/residential

PM_{10}

We installed and commissioned a nephelometer (PM_{10}) monitor at Site 1 in December 2017.

In the morning of 31 January, we noted unusual concentrations of PM_{10} between 2 and 3am earlier that day. The patterns of variation were inconsistent with previous data from this site. The following morning, the landowner contacted Mote to advise that part of the equipment at the site had been moved. A visit was scheduled for the following day (Thursday 1 February).

The site visit revealed:

> *When we inspected the site on Thursday 1 February, we established that the monitoring enclosure had been opened and the RCS monitoring instrument had been moved (turned upside down). The tamper-proof tape around the monitoring enclosure had been removed and the clips securing the enclosure had been opened. On the basis of this evidence, we concluded that the enclosure had been tampered with. We have left the current RCS filter in-situ at the present time. No other data connectivity issues were noted with this site during this period.*

As a consequence of the tampering, we invalidated data from the instrument for the period 2-3 am on 31 January 2018 and replaced the RCS filter. With the permission of the land-owner, additional security precautions have now been taken at this site.

Figure 5 presents hourly $PM_{10}$for site 1 for the period 22 January – 21 February 2018. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) during this monitoring period at Site 1.

Figure 6 presents daily PM_{10} measured by the nephelometer between 22 January and 21 February 2018.

NB: Nephelometers are not reference instruments. This means we cannot directly compare PM_{10} data from nephelometers in **Figure 6** with the 24-hour average national PM_{10} standard.

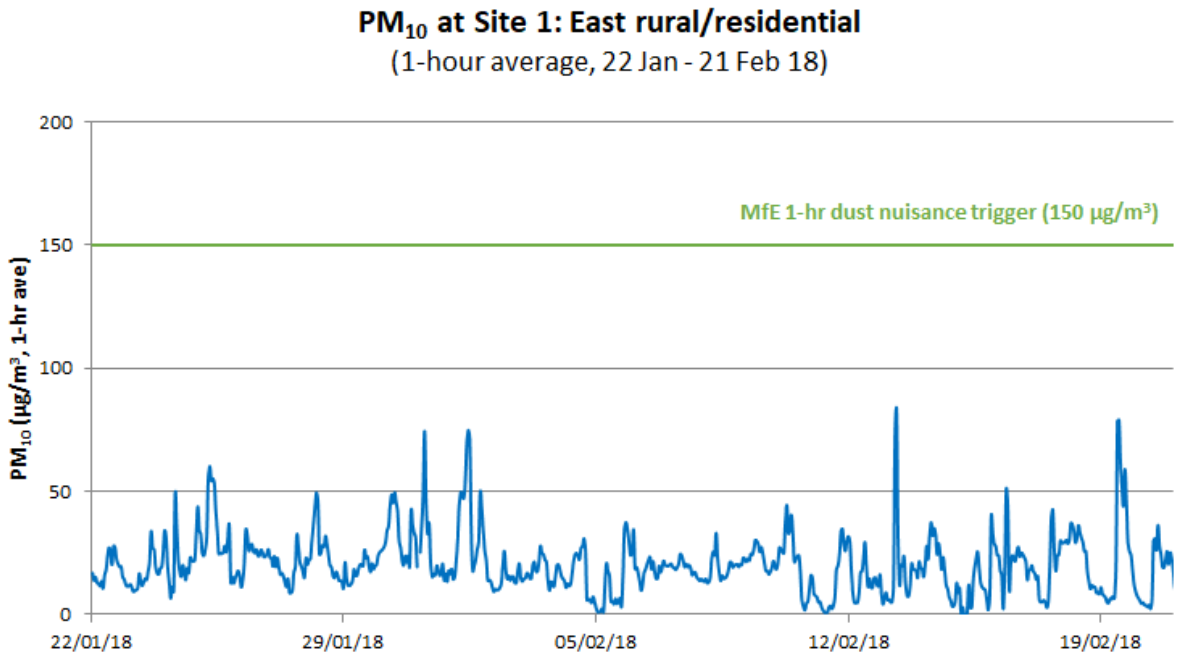

Figure 5 Hourly PM_{10} (nephelometer) at Site 1: East rural/residential for period 22 Jan - 21 Feb 2018

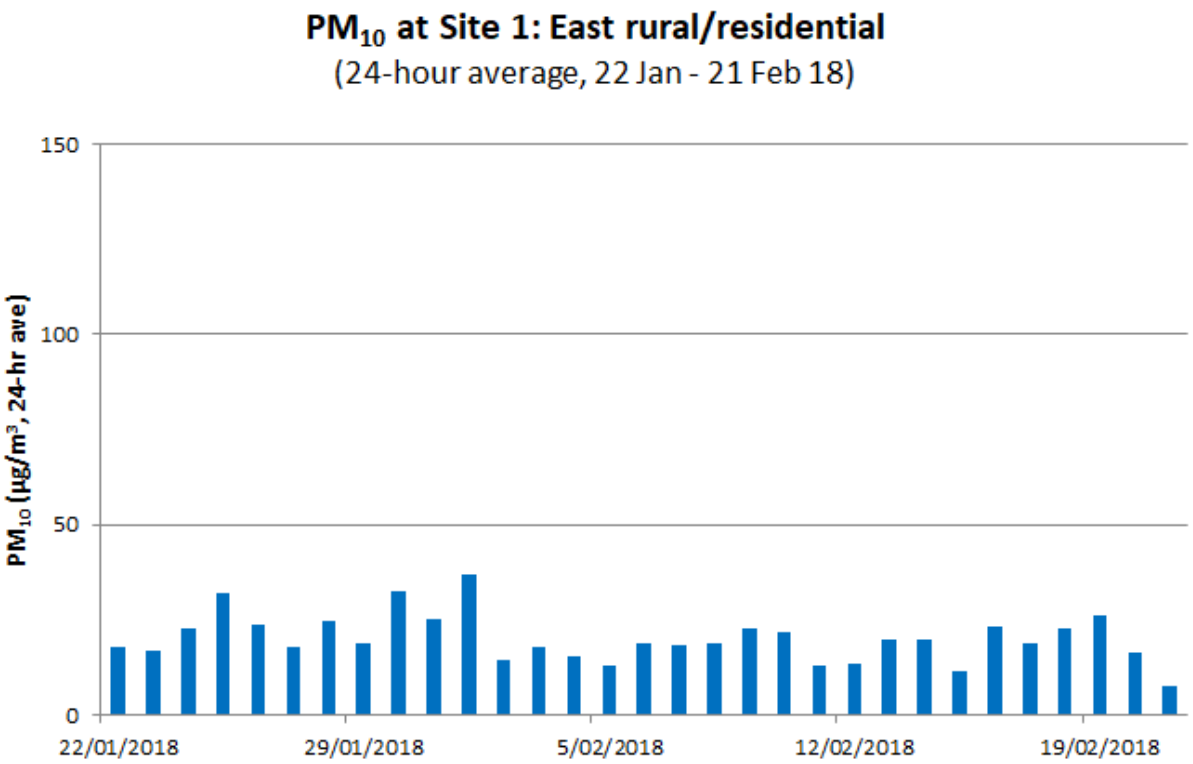

Figure 6 Daily PM_{10} (nephelometer) at Site 1: East rural/residential for period 22 Jan - 21 Feb 2018

2.2 Site 2: North (east) rural/residential

PM_{10} and $PM_{2.5}$

We installed and commissioned two nephelometer (PM_{10} and $PM_{2.5}$) monitors at Site 2 on 15 December. These were fully operational from 16 December 2017.

We installed and commissioned a beta attenuation monitor (BAM) reference method PM_{10} monitor at Site 2 on 20 December 2017. This was fully operational from 21 December 2017.

Shortly after midday on 1 February we lost contact with all instruments at Site 2. An investigation revealed that there had been a power outage which also tripped the residual current device (RCD) at the site. The RCD was reset the following day around midday.

Due to this power outage approximately 24 hours of data were lost from the PM_{10} and $PM_{2.5}$ nephelometers, the meteorological station and the BAM at Site 2.

Figure 7 presents hourly PM_{10} from the nephelometer (blue) and BAM (pink) for the period when both were monitoring side by side from 22 January – 21 February 2018. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) during this monitoring period at Site 2.

Figure 8. presents daily PM_{10} measured by the nephelometer and the BAM (reference method) between 22 January – 21 February 2018. There were no exceedances of the NES for PM_{10} measured by the BAM during this period at Site 2.

Figure 9. presents PM_{10} measured by BAM as a function of PM_{10} measured by nephelometer for available validated days of data at Site 2. This correlation suggests the nephelometer is over-reading actual PM_{10} levels when compared with the reference method.

Figure 10. presents hourly $PM_{2.5}$ measured by nephelometer at Site 2 for the period of operation (22 January – 21 February 2018).

Figure 11. presents daily $PM_{2.5}$ at Site 2 for this same period.

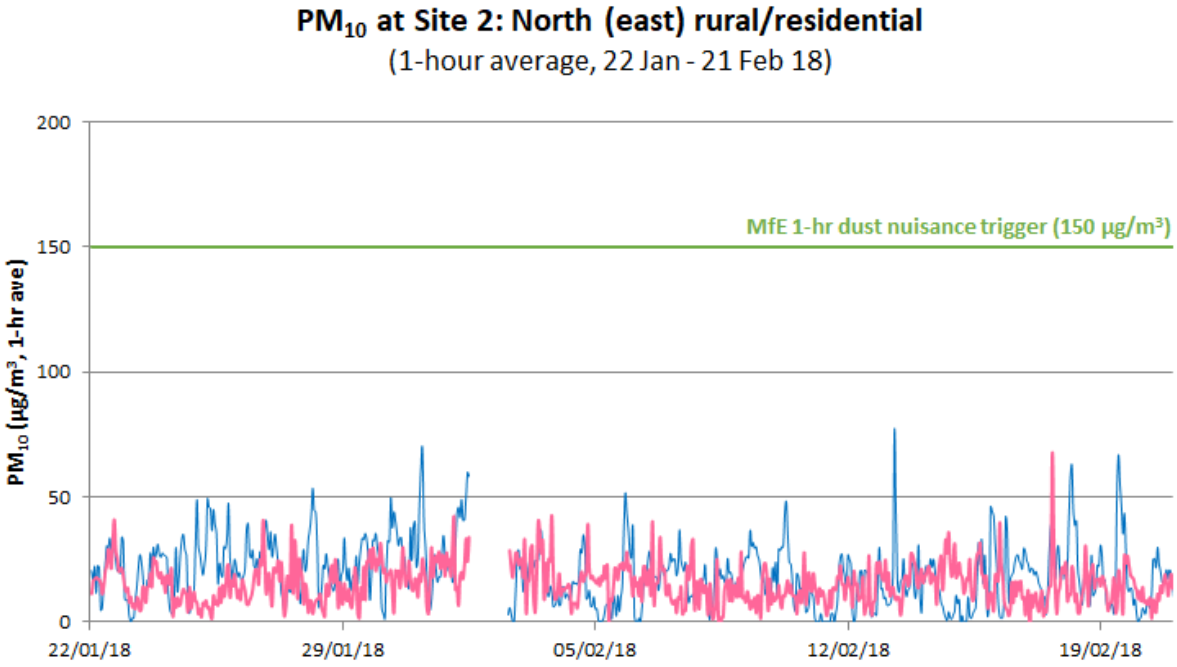

Figure 7 Hourly PM_{10} nephelometer (thin blue) and BAM (pink) at Site 2: North (east) rural/residential for period 22 Jan - 21 Feb 2018

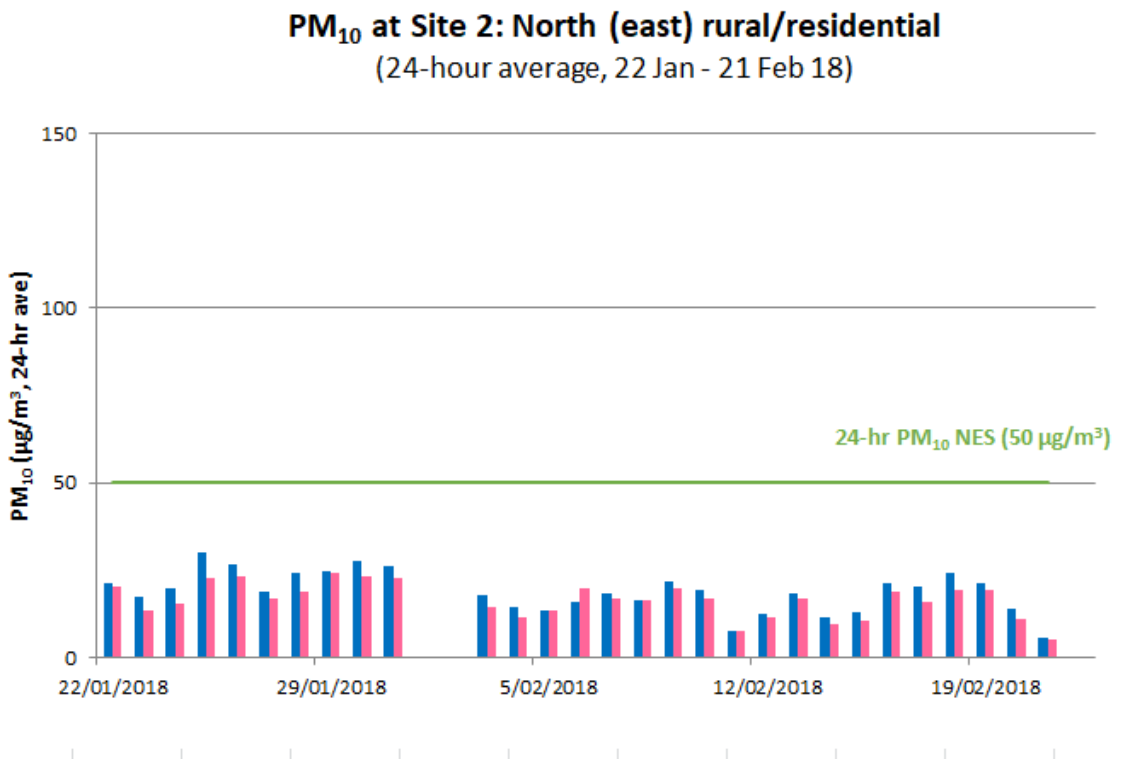

Figure 8 Daily PM_{10} nephelometer (blue) and BAM (pink) at Site 2: North (east) rural/residential for period 22 Jan - 21 Feb 2018

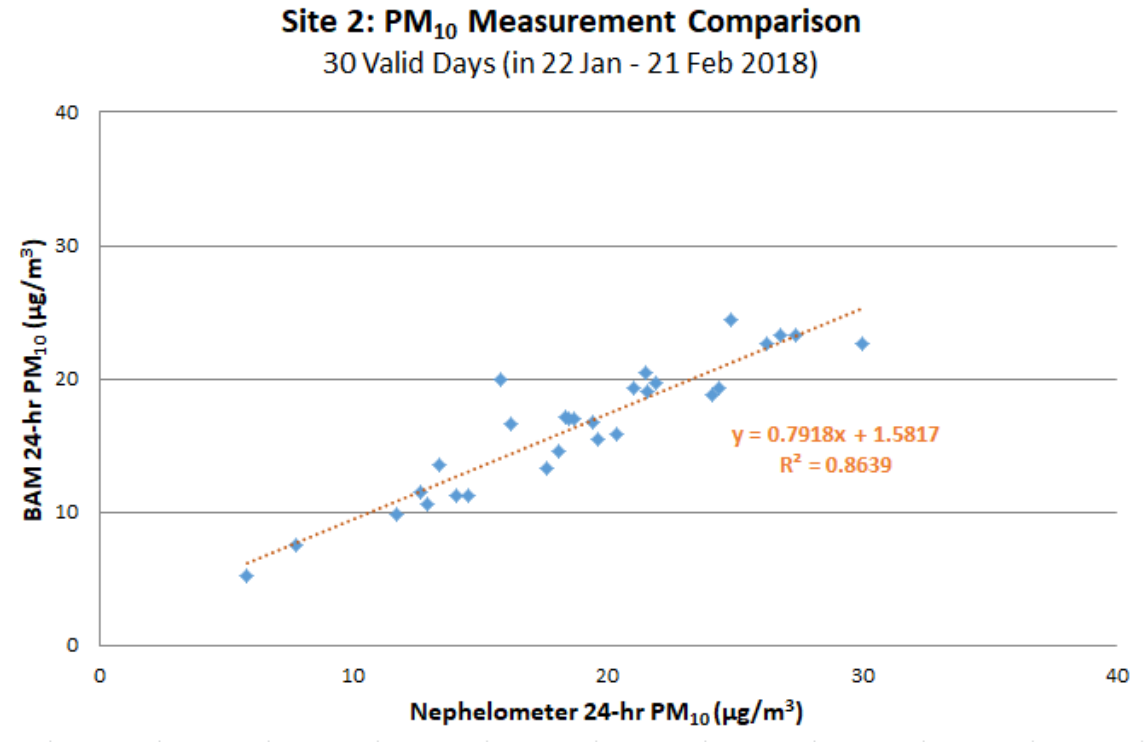

Figure 9 Daily PM_{10} measured by nephelometer as a function of daily PM_{10} measured by BAM at Site 2: North (east) rural/residential for (validated data) period 22 Jan - 21 Feb 2018

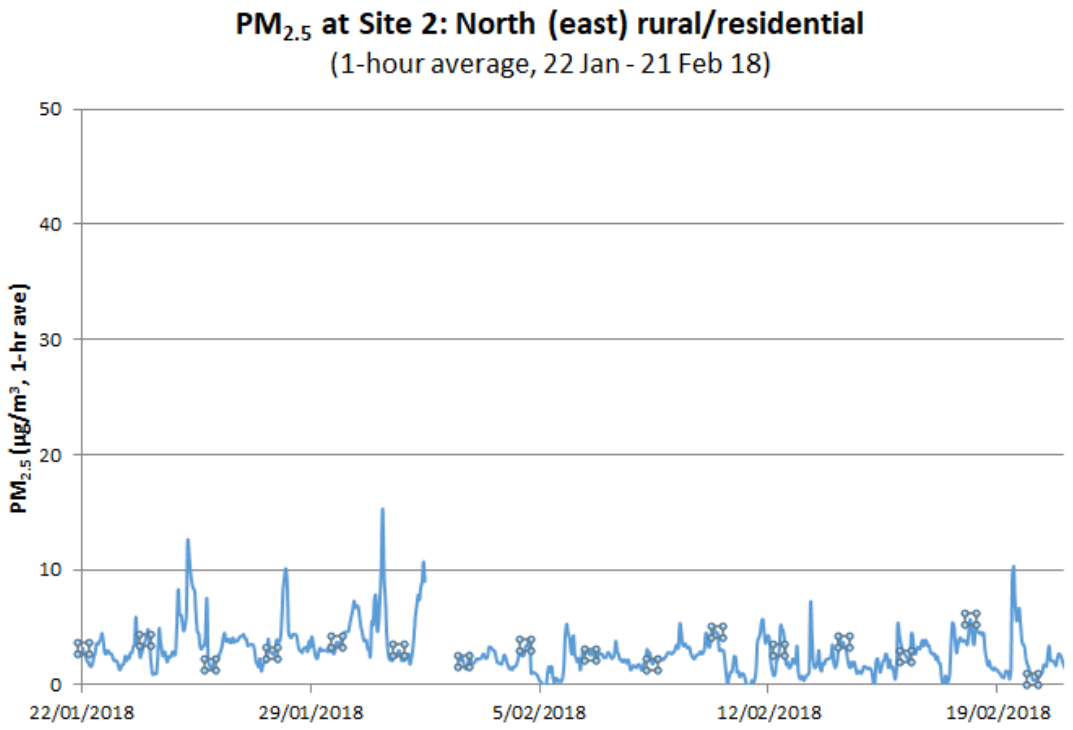

Figure 10 Hourly $PM_{2.5}$ nephelometer at Site 2: North (east) rural/residential 22 Jan - 21 Feb 2018

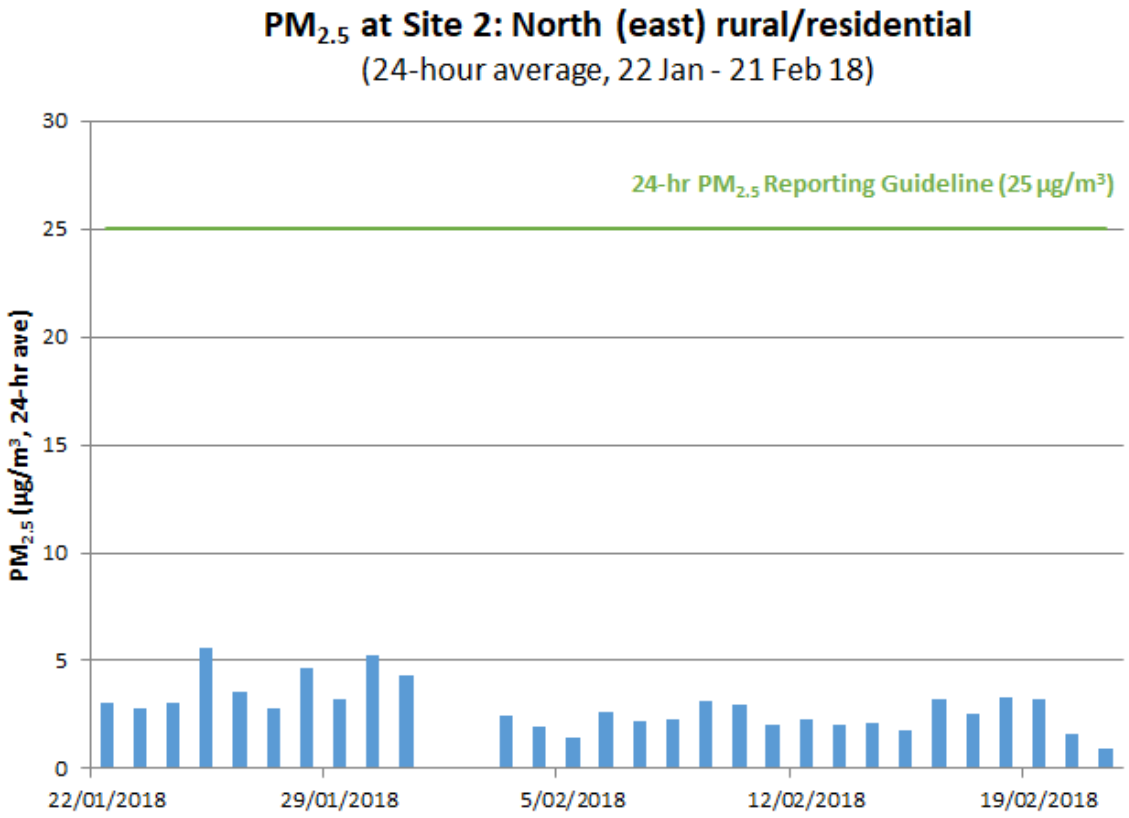

Figure 11 Daily $PM_{2.5}$ nephelometer at Site 2: North (east) rural/residential 22 Jan – 21 Feb 2018

Meteorology

We installed and commissioned a meteorological monitoring station at Site 2 on 21 December 2018. This was fully operational from 22 December 2017.

Figure 12. presents wind direction and wind speed measured at Site 2 for the period 23 January – 24 February 2018.

Figure 13 presents rain data measured at Site 2 for the same period.

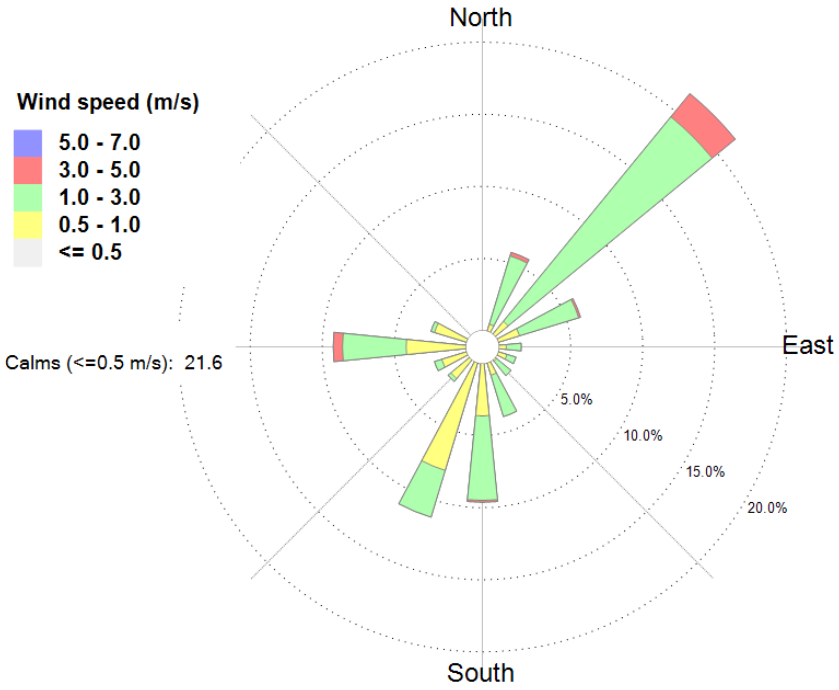

Figure 12 Wind direction and wind speed measured at Site 2: North (east) rural/residential for period 22 Jan – 21 Feb 2018

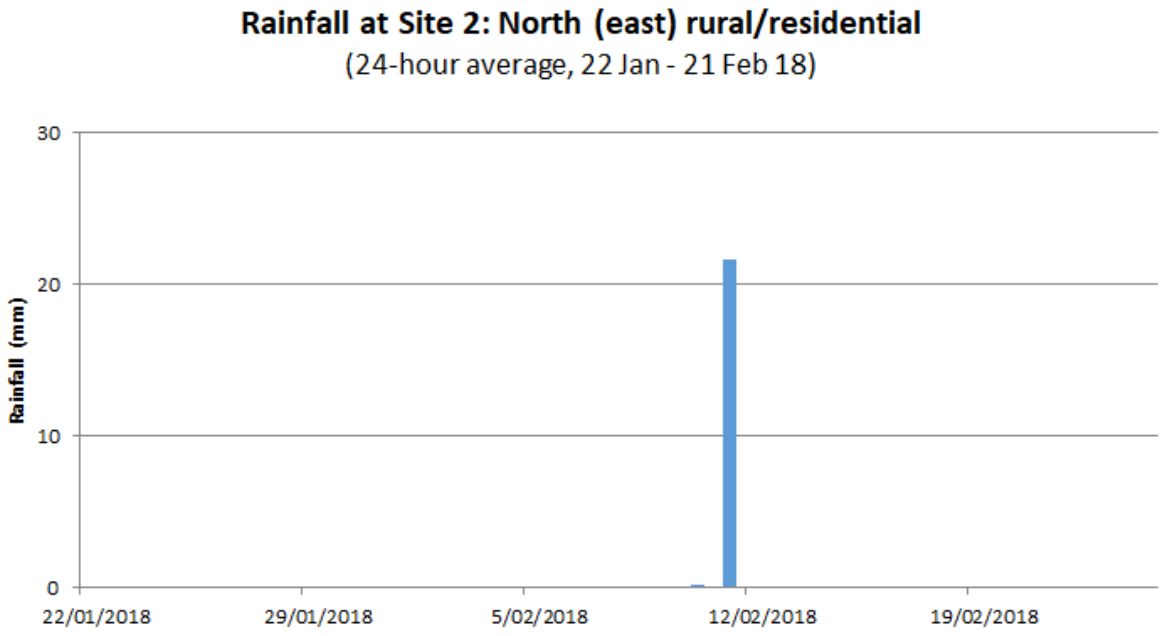

Figure 13 Bar chart of rainfall at Site 2: North (east) rural/residential for period 22 Jan – 21 Feb 2018

2.3 Site 3: South (east) rural

PM_{10} and $PM_{2.5}$

We installed and commissioned a PM_{10} nephelometer monitor at Site 3 on 15 December and it was fully operational from 16 December 2017. We installed and commissioned a $PM_{2.5}$ nephelometer on 21 December and it was fully operational from 22 December 2017.

Figure 14 presents hourly PM_{10}. There was one exceedance (283 µg/m^3) of the 1-hour suggested trigger threshold (150 µg/m^3) between midday and 1pm on 1 February 2018. This was the same day that an exceedance of the suggested trigger threshold was measured at Site 5 and coincided with a strong north-westerly wind change.

Figure 15 presents one-minute PM_{10} and wind direction data during the exceedance on 1 February 2018.

Figure 16 presents daily PM_{10} measured by the nephelometer between 22 January and 21 February 2018.

NB: As noted above, daily PM_{10} measured by a nephelometer cannot be directly compared with the national environmental standard for PM_{10}.

Figure 17 and **Figure 18** present hourly and daily $PM_{2.5}$ for 22 January 2018 and 21 February 2018.

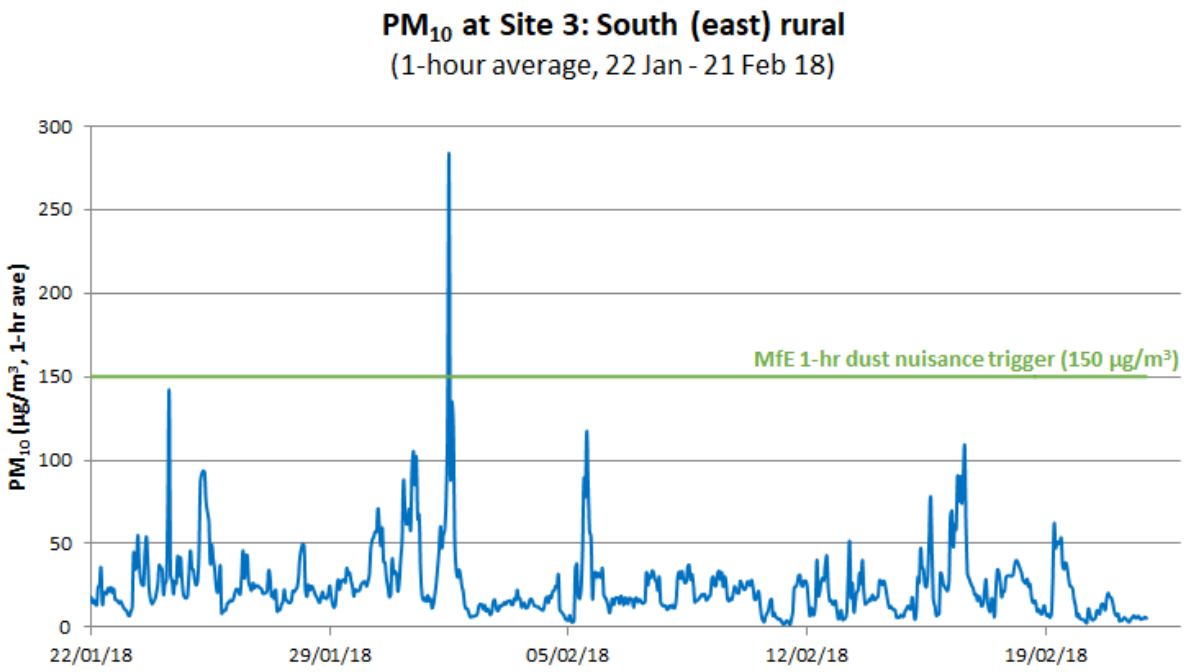

Figure 14 Hourly PM_{10} (nephelometer) at Site 3: South (east) rural for period 22 Jan - 21 Feb 2018

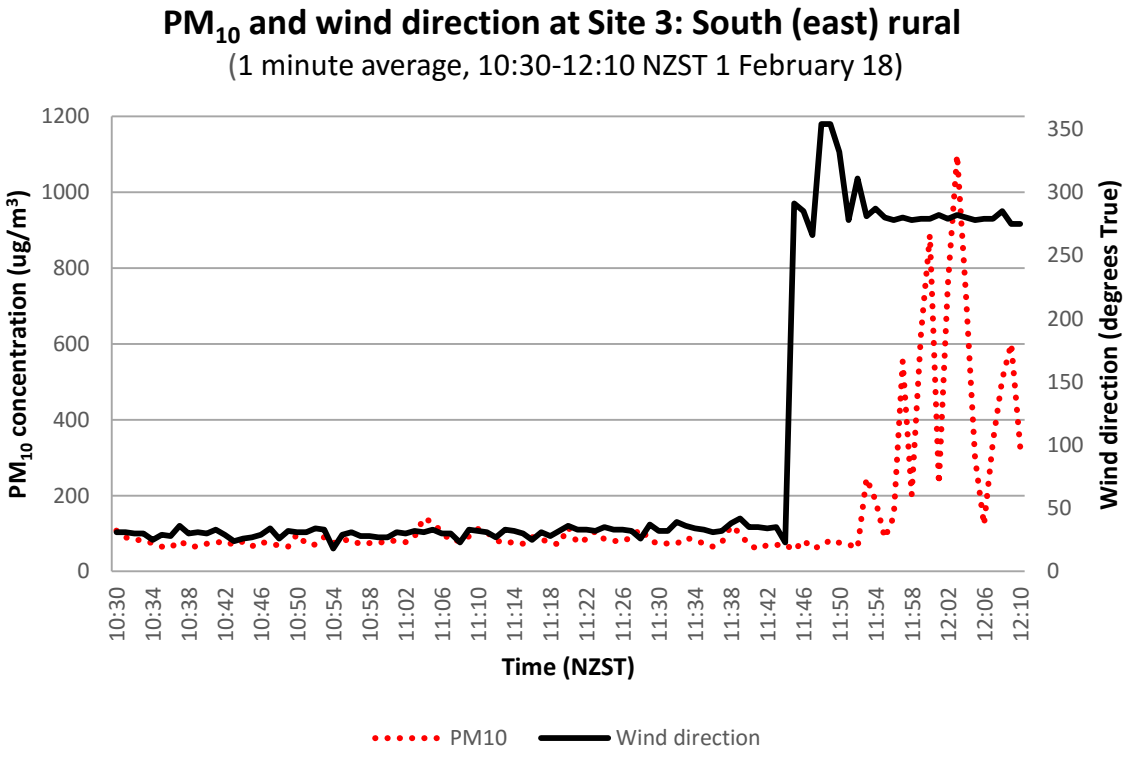

Figure 15 One minute PM_{10} (nephelometer) and wind direction at Site 3: South (east) rural on 1 February 2018 during an exceedance event.

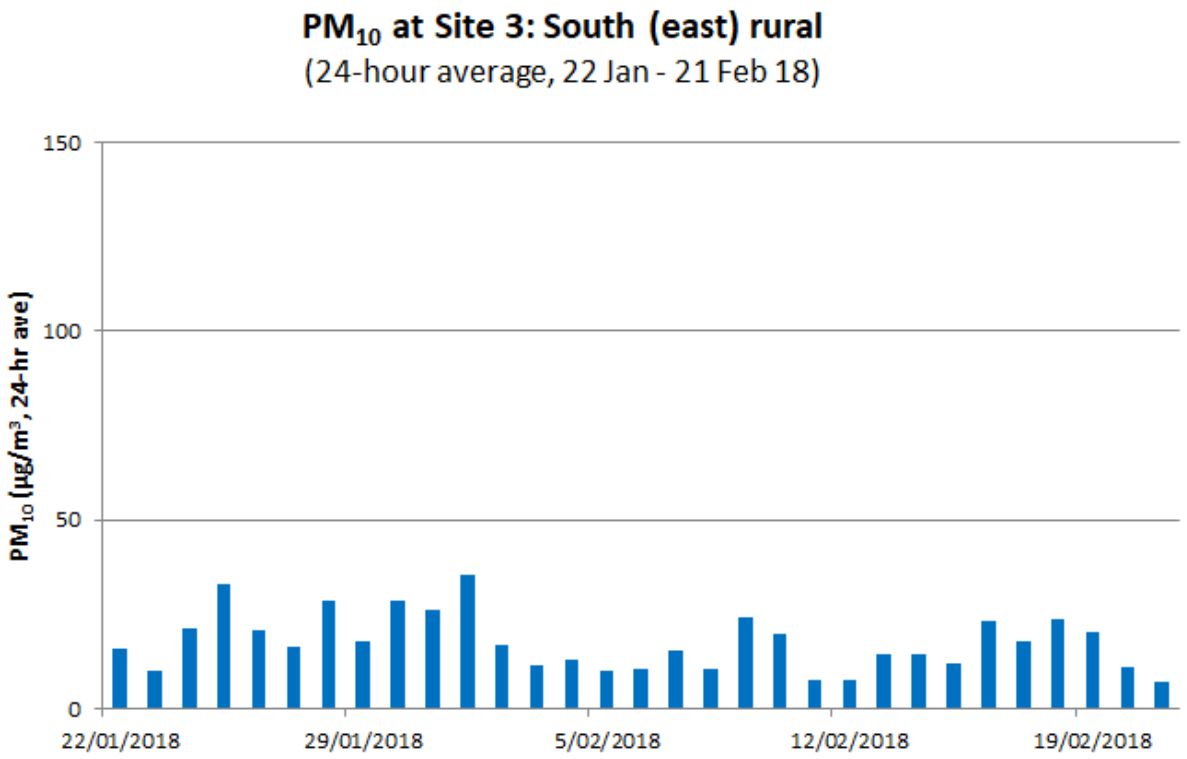

Figure 16 Daily PM_{10} (nephelometer) at Site 3: South (east) rural for period 22 Jan - 21 Feb 2018.

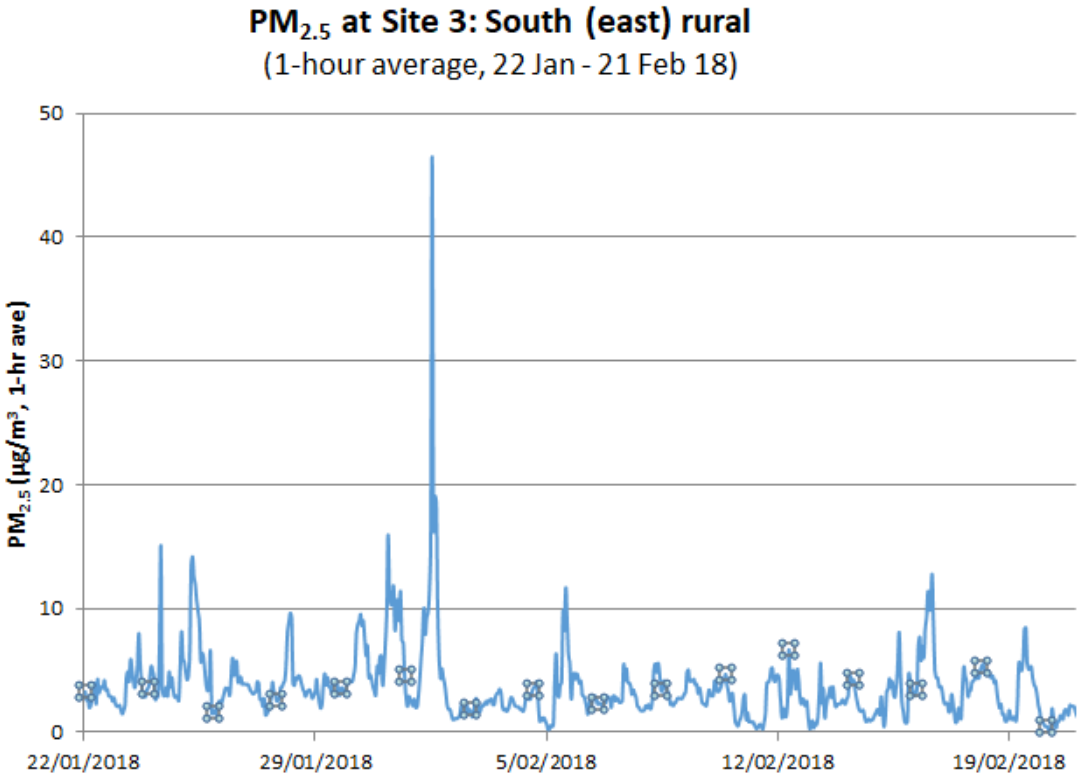

Figure 17 Hourly $PM_{2.5}$ (nephelometer) at Site 3: South (east) rural for period 22 Jan - 21 Feb 2018

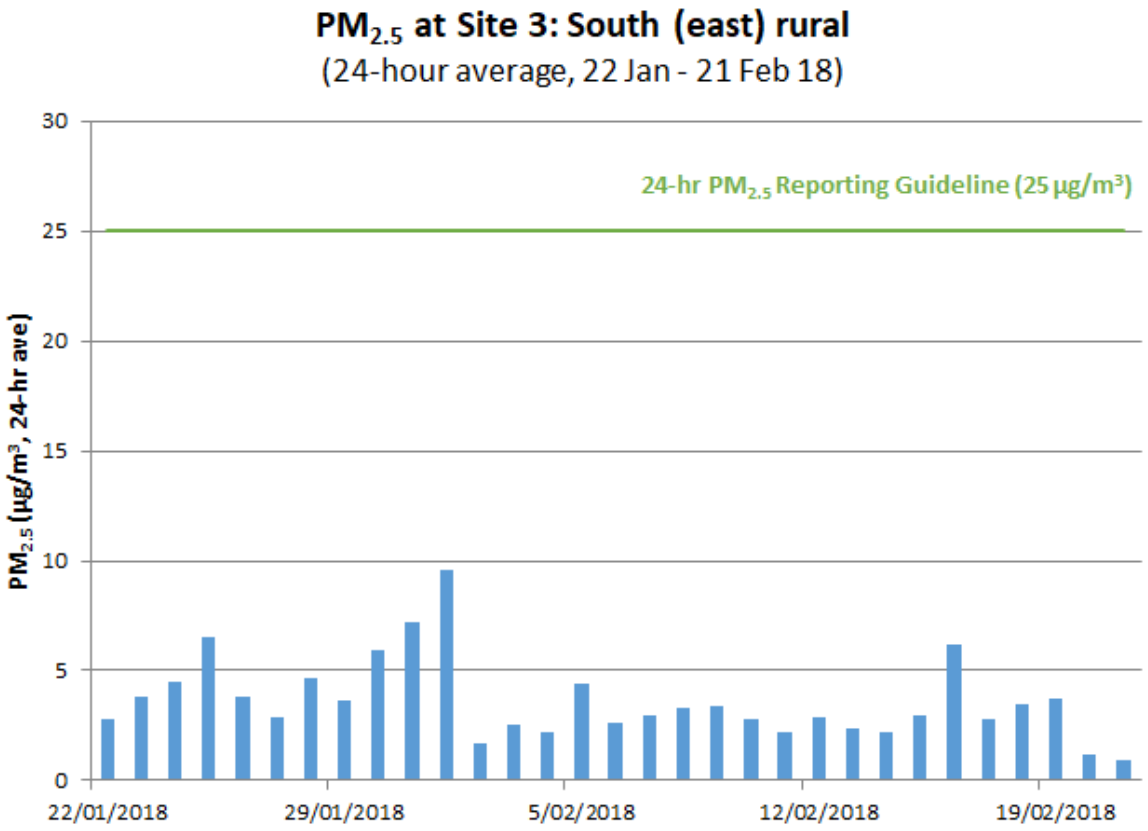

Figure 18 Daily $PM_{2.5}$ (nephelometer) at Site 3: South (east) rural for period 22 Jan - 21 Feb 2018

2.4 Site 4: Background rural/residential

PM_{10} and $PM_{2.5}$

We installed and commissioned a nephelometer (PM_{10}) monitor and BAM at Site 4 on 14 December 2017. These were fully operational from 15 December 2017.

Figure 19 presents hourly PM_{10} from the nephelometer (blue) and BAM (pink) for the period 23 January 2018 and 24 February 2018. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) during this monitoring period at Site 4.

Figure 20 presents daily PM_{10} measured by the nephelometer and the BAM (reference method) between 23 January 2018 and 24 February 2018. There were no exceedances of the NES for PM_{10} measured by the BAM during this period at Site 4.

Figure 21 presents PM_{10} measured by BAM as a function of PM_{10} measured by nephelometer for available validated (30) days of data at Site 4. This correlation suggests the nephelometer is over-reading actual PM_{10} levels when compared with the reference method.

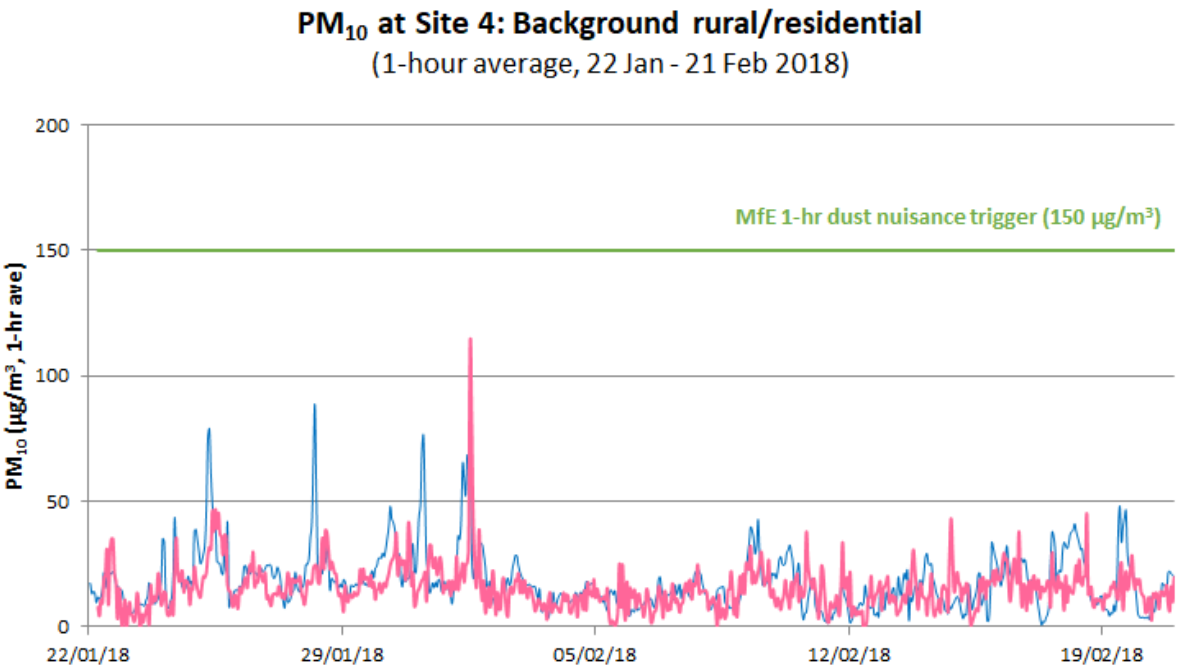

Figure 19 Hourly PM_{10} nephelometer (thin blue) and BAM (pink) at Site 4: Background rural for period 22 Jan - 21 Feb 2018

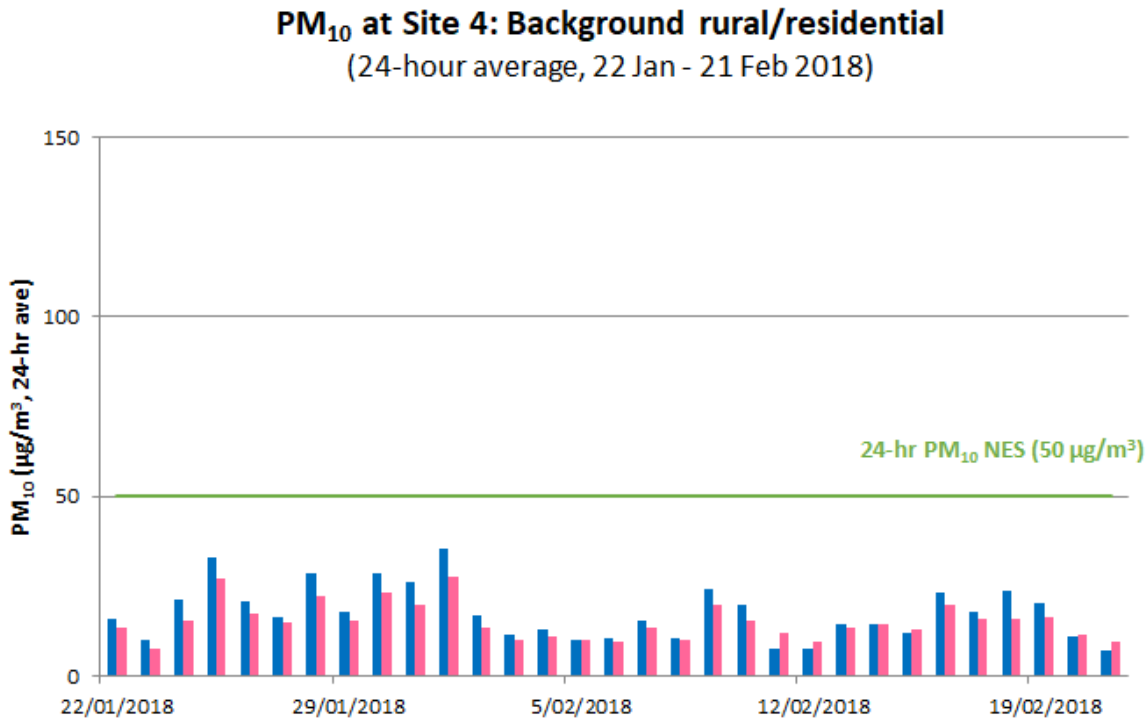

Figure 20 Daily PM_{10} nephelometer (thin blue) and BAM (pink) at Site 4: Background rural for period 22 Jan 2018 – 21 Feb 2018

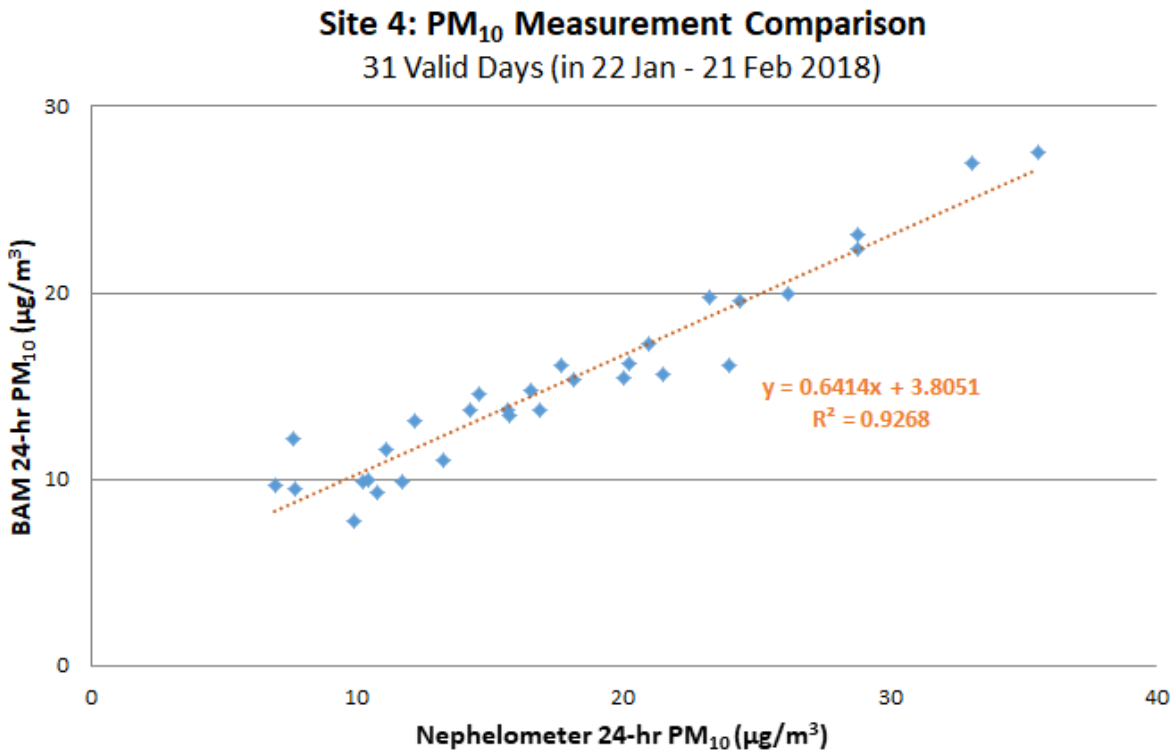

Figure 21 Daily PM_{10} measured by nephelometer as a function of daily PM_{10} measured by BAM at Site 4: Background rural/residential for (validated data) period 22 Jan - 21 Feb 2018

Figure 21 presents hourly $PM_{2.5}$ measured by nephelometer at Site 4 for the period of operation (22 Jan - 21 Feb 2018)

Figure 22 presents daily $PM_{2.5}$ measured by nephelometer at Site 4 for the period of operation (22 Jan - 21 Feb 2018)

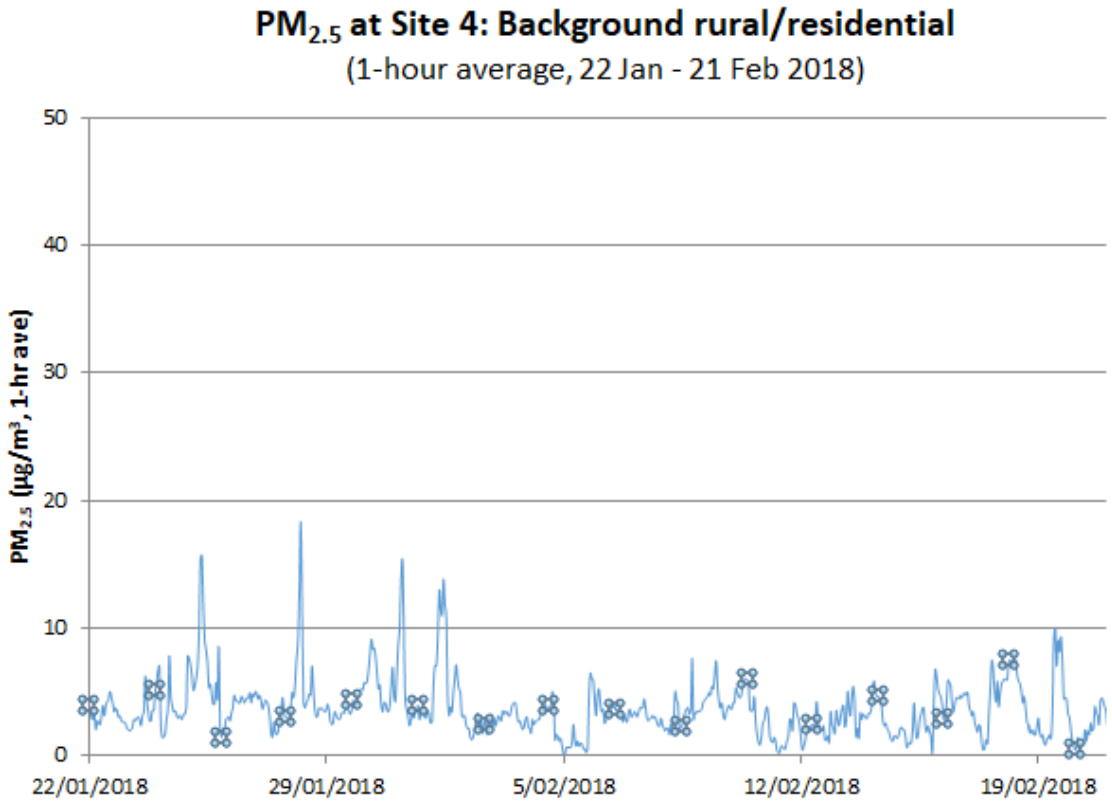

Figure 22 Hourly $PM_{2.5}$ nephelometer at Site 4: Background rural/residential for period 22 Jan - 21 Feb 2018

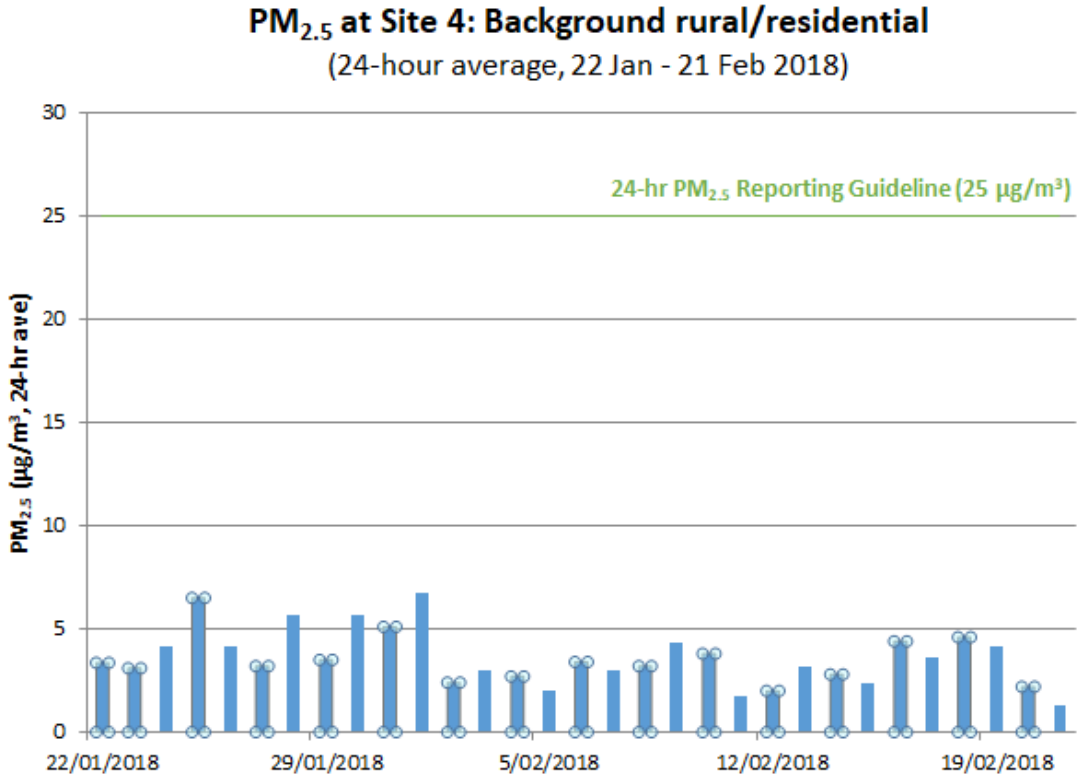

Figure 23 Daily $PM_{2.5}$ nephelometer at Site 4: Background rural/residential for period 22 Jan - 21 Feb 2018

2.5 Site 5: South (west) rural

We installed and commissioned a PM_{10} nephelometer monitor at Site 5 on 15 December and it was fully operational from 16 December 2017.

Figure 24 presents hourly PM_{10}. There were two exceedances (172 & 204 µg/m^3) of the 1-hour suggested trigger threshold (150 µg/m^3) between 11:00 and 1pm on 1 February 2018. This was the same day that an exceedance of the suggested trigger threshold was measured at Site 3 and coincided with a strong north-westerly wind change.

Figure 25 presents one minute PM10 and wind direction data during the exceedances on 1 February 2018.

Figure 26 presents daily PM_{10} measured by the nephelometer between 22 January 2018 and 21 February 2018.

NB: As noted above, daily PM_{10} measured by a nephelometer cannot be directly compared with the national environmental standard for PM_{10}.

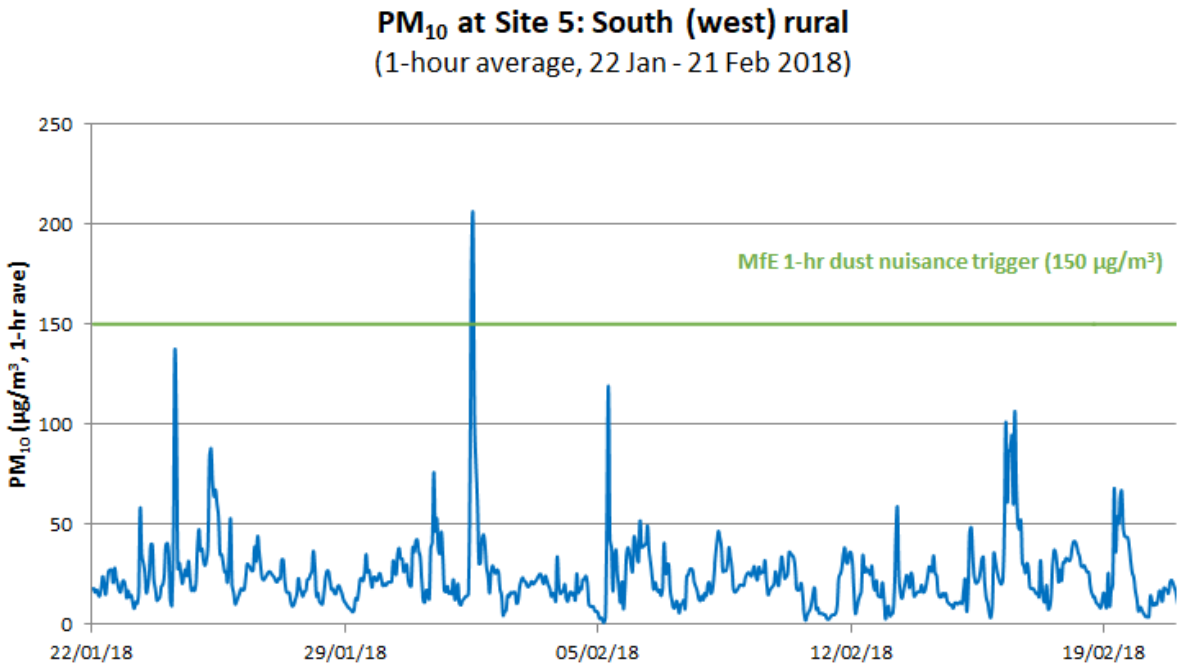

Figure 24 Hourly PM_{10} (nephelometer) at Site 5: South (west) rural for period 22 Jan – 21 Feb 2018

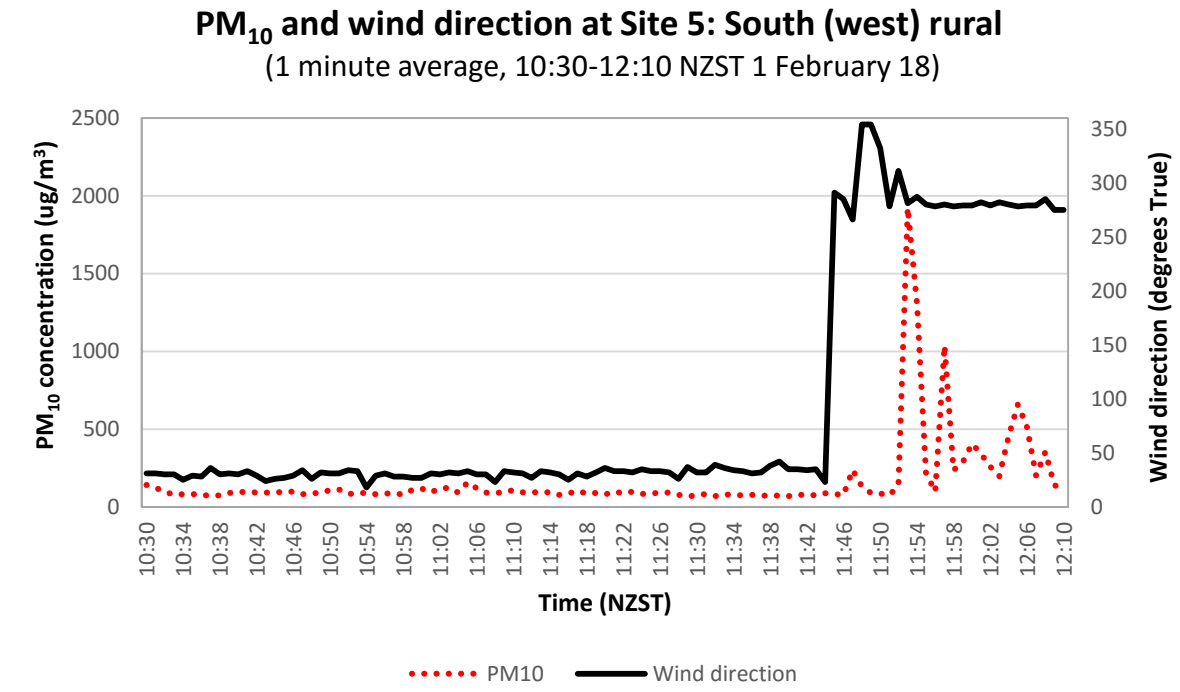

Figure 25 One minute PM10 (nephelometer) and wind direction at Site 5: South (west) rural on 1 February 2018 during an exceedance event.

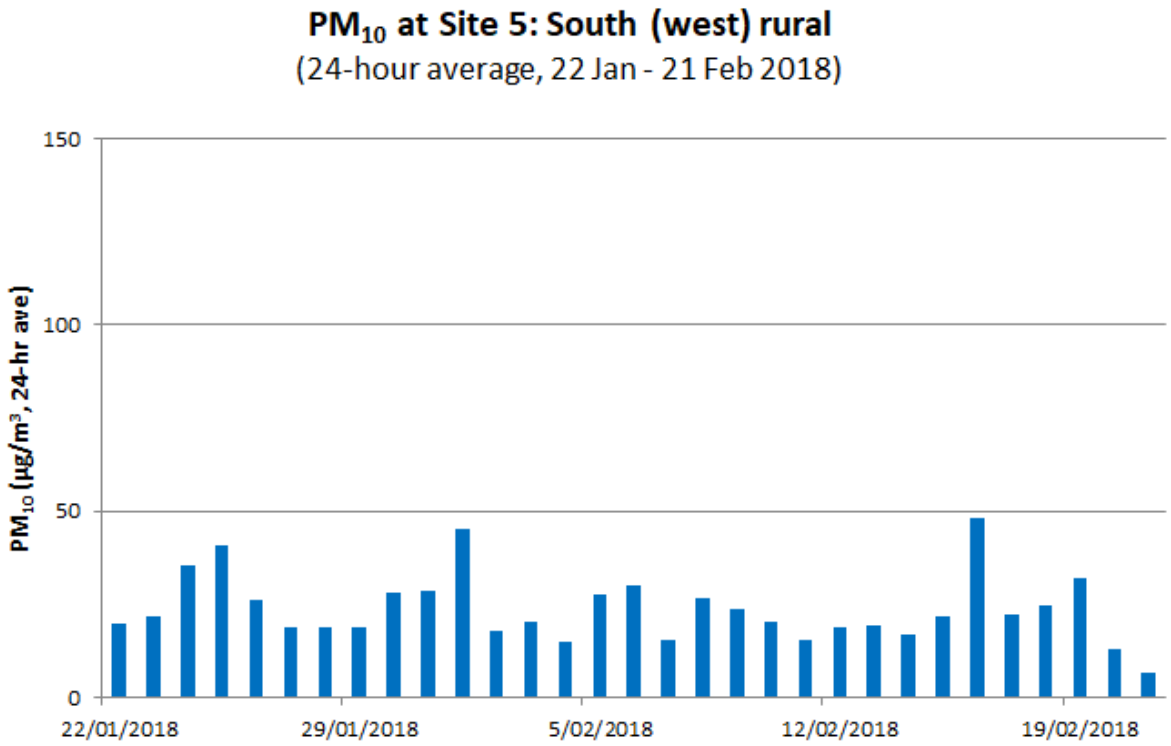

Figure 26 Daily PM_{10} (nephelometer) at Site 5: South (west) rural for period 22 Jan - 21 Feb 2018

2.6 Site 6: North (west) rural/residential

Installation of a PM_{10} nephelometer at Site 6 was initially delayed through a communication error (our email went into the residents spam filter). A follow-up visit saw the successful installation of a nephelometer on 22 December 2017. Unfortunately, however, cellular reception was insufficient for the modem to transmit data.

On Friday 12 January 2018 we installed a passive gain antennae, however while the signal strength improved, it was insufficient for data transmission.

The following week on Friday 19 January, we raised the height of the antenna and installed an active gain antenna to compensate for the increase in cable length. Unfortunately, we were unable to obtain sufficient signal strength at Site 6 to permit cellular communication. This is unusual as installing a pole mounted active antennae usually resolves such problems.

Whilst we checked cellular reception prior to recommending this location, the issue arose from a small change in the monitoring site location at the request of the homeowner. It was not until we commenced commissioning that we encountered the challenges involved with poor cellular reception. It was similarly, unusual not to be able to resolve this through installing an active gain antennae, or by raising the antennae height.

Irrespective of the issues with connectivity, there were no data loss issues with this site as we could still retrieve the data manually.

On 22 January 2018, we notified Environment Canterbury that this site was non-functional with respect to connectivity and received approval to relocate the nephelometer and RCS monitoring to a new site as soon as possible. The new Site 6A is sufficiently close (< 300 metres) that the location for Site 6 shown in **Figure 1** is still indicative.

Figure 27 presents hourly PM_{10} for Site 6. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) between 22 January 2018 and 21 February 2018.

Figure 28 presents daily PM_{10} measured by the nephelometer at Site 6 for this period.

NB: As noted above, daily PM_{10} measured by a nephelometer cannot be directly compared with the national environmental standard for PM_{10}.

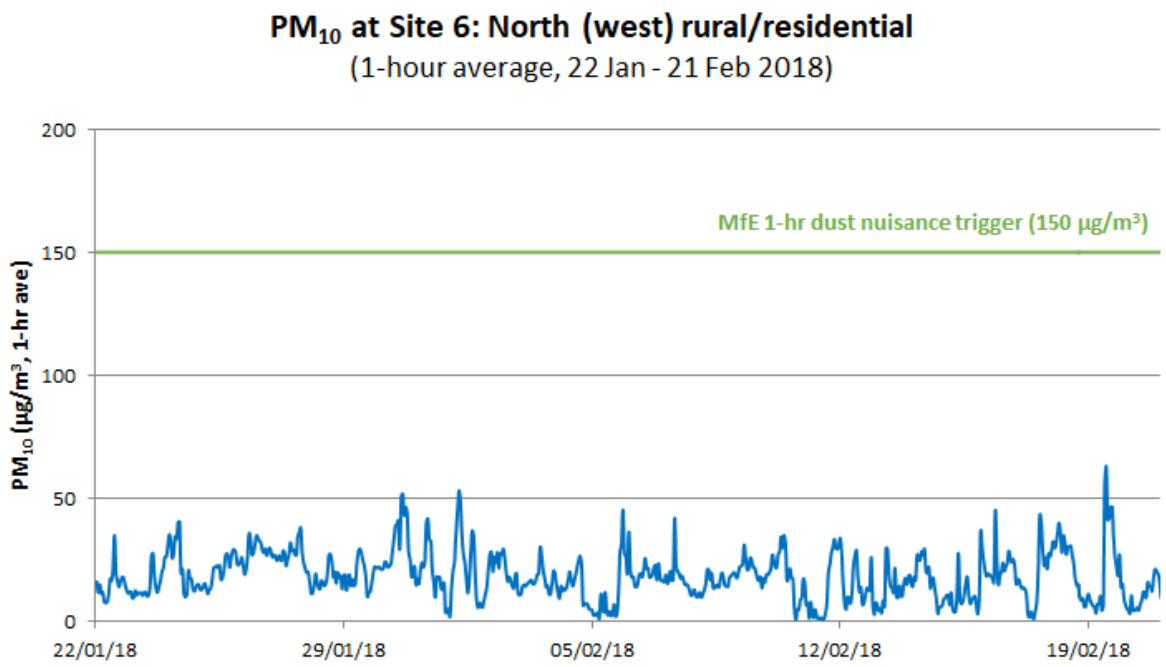

Figure 27 Hourly PM_{10} (nephelometer) at Site 6: North (west) rural/residential for period 22 Jan - 21 Feb 2018

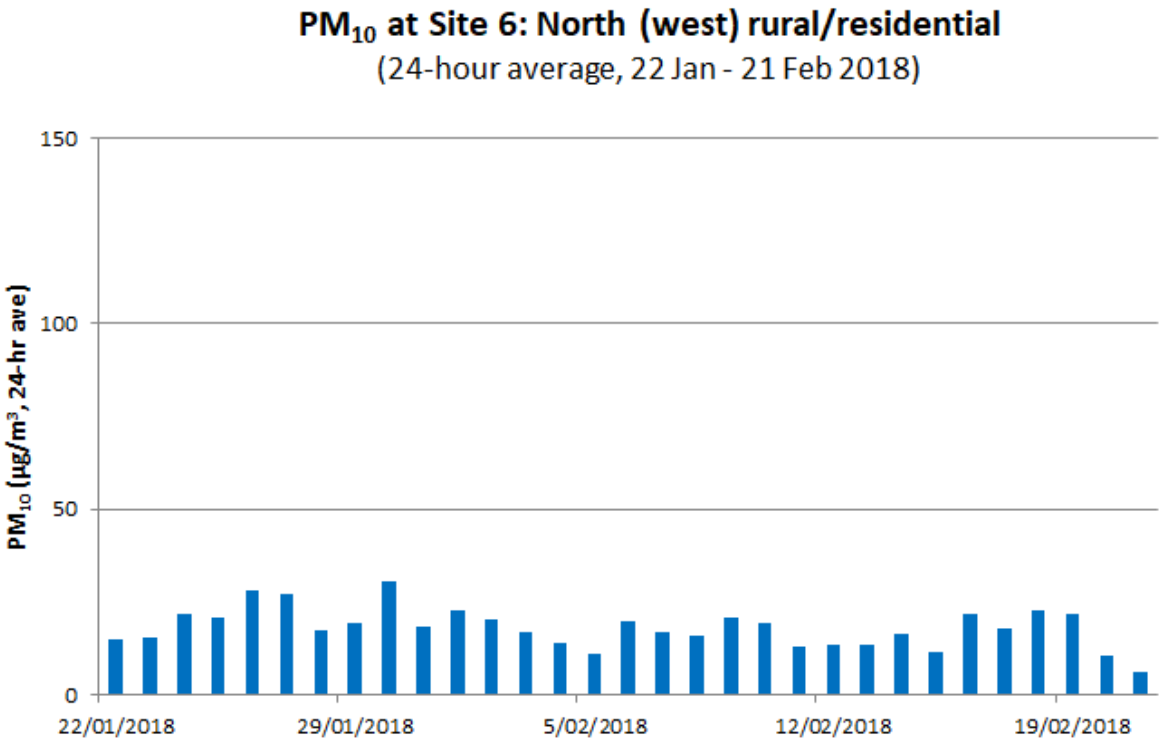

Figure 28 Daily PM_{10} (nephelometer) at Site 6: North (west) rural/residential for period 22 Jan– 21 Feb 2018

2.7 Transect monitors

A series of PM_{10} nephelometers were deployed to the south-east of the Site 3 monitor. The intent of this monitoring is to estimate the reduction (if any) in PM_{10} levels in the vicinity of the quarries.

These "transect" monitors are deployed roughly along a line to the south-east of current quarry operations and are intended to investigate PM_{10} levels downwind of the quarries during strong north-westerly winds events. The monitors were originally intended to extend up to 1 kilometre from the quarry boundary, however, practical considerations have meant that the last monitor is situated approximately 650 metres south of the quarries.

The transect monitors are located as shown in Table 3.

Table 3 Location and site details of transect monitors

Location	Installation date	Distance from quarry
Site 3	16 December 2017	50m
Transect 1	9 February 2018	250m
Transect 2	9 February 2018	500m
Transect 3	9 February 2018	650m

A combined plot displaying the hourly average PM_{10} at each of the transect sites is shown below in **Figure 29**.

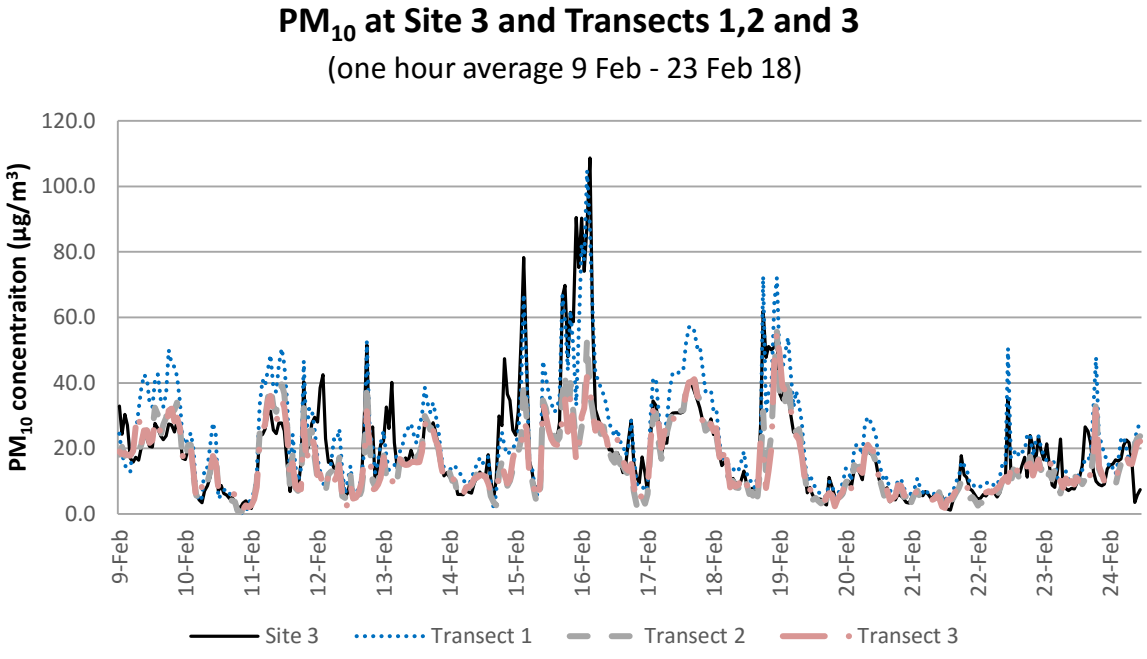

Figure 29 Hourly PM_{10} (nephelometer) at the transects south of the quarries for period 9 - 21 Feb 2018

2.8 Summary

There were three exceedances of the suggested PM_{10} trigger threshold for dust nuisance measured at two locations between 22 January and 21 February 2018.

These events occurred at sites 3 and 5, which are situated to the south of the quarries. The exceedances coincided with a north-westerly wind change. Details of the exceedances are outlined in Table 4 below.

Table 4 Summary Elevated Particulate Levels 22 Jan - 21 Feb 2018

Site	Location	Date / Time[1]	Conc ($\mu g/m^3$)	Wind Dir	Wind Speed (km/hr)	Comment
Suggested PM_{10} trigger threshold for dust nuisance = 150 $\mu g/m^3$ as a 1-hour average						
5	South (west)	1 Feb 11:00 – 12:00	173	North-westerly	43	Strong NW wind change
5	South (west)	1 Feb 12:00 – 13:00	205	North-westerly	43	Strong NW wind change
3	South (east)	1 Feb 12:00-13:00	284	North-westerly	43	Strong NW wind change

Notes

[1] New Zealand standard time (NZST) – add one hour to get to New Zealand daylight savings time

The change in wind direction can been seen in **Figure 30** which follows. The wind direction undergoes a significant change in direction at 11:44 am. The event is also associated with a sudden drop in wind speeds.

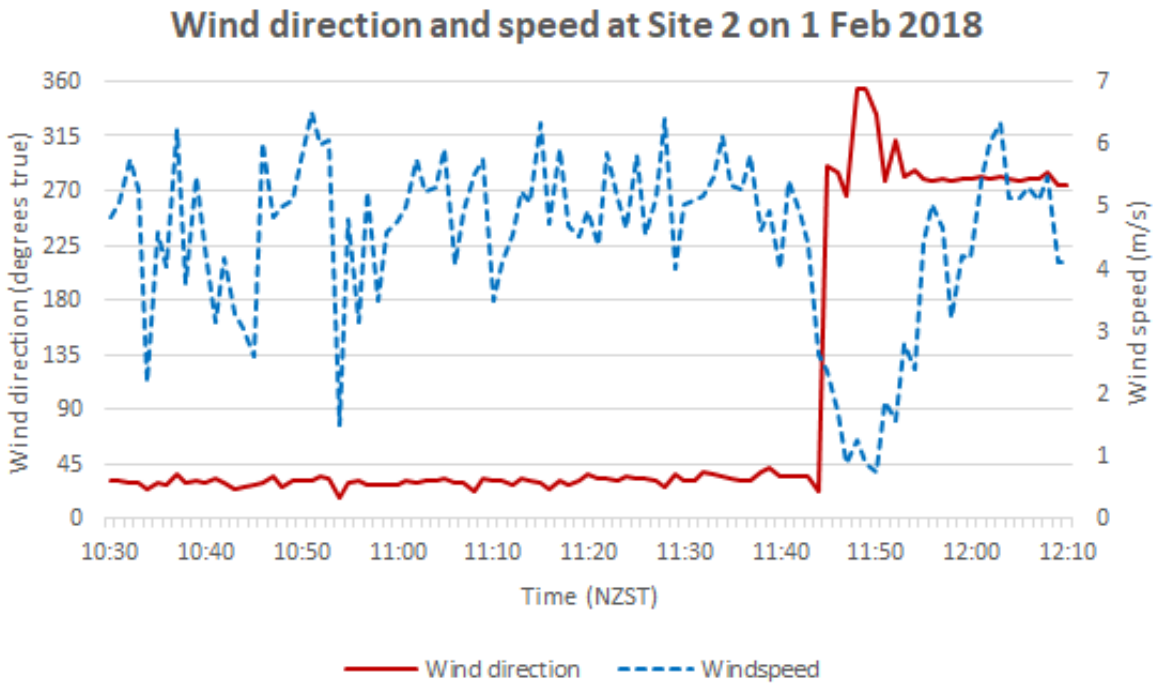

Figure 30 One minute wind data from Site 2 illustrating the shift in wind direction (red line) and the drop in wind speeds (dotted blue line) which coincided with the change in wind direction.

2.9 Quarry Operations

At our meeting with the quarries on 7 November 2017 we requested monitoring and operational data to inform the Yaldhurst monitoring programme. The quarry representatives responded positively to this request.

However, we have been unable to obtain operational data from the quarries to date.

2.10 Complaints data

Table 6 presents Environment Canterbury's record of dust complaints during the monitoring period.

The complaints on 1st February 2018 coincided with an exceedance of the suggested dust nuisance trigger threshold at sites 3 and 5.

Table 5 Dust complaints received by Environment Canterbury 22 Jan -21 Feb 2018

Complaint Received Date	Incident Start Date	Incident Start Time	Description of Incident	No. Complaints	General Location Description
23 Jan 18	23 Jan 18	11:50	23/01/2018 11:50am - [Dust SOL Quarries] - Caller reports large quantities of dust coming out of SOL Quarries and from trucks coming out of there are blowing it everywhere. Noticed just now. Caller did not know name of road (likely Guys Road).	1	Conservators Road, Yaldhurst, Christchurch
01 Feb 18	01 Feb 18	12:05	01/02/2018 12:05pm Customer rang to complain about the amount of dust that is blowing around from all of the quarries in the area of Conservators Raod, Yaldhurst. He mentioned, Frews, SOL and Fulton Hogan. ** Call 2** 2/2/2017 11.00a.m. Email received 1/02/2018 6:01 p.m. Hi, I'm looking to make a complaint about dust leaving the boundary of Sol Quarry on Guys Rd/Conservators Road. Dust plumes are visible above the quarry and are visibly leaving the boundary (witnessed 5:15pm). Dust also blowing off haul road. No visible dust suppressant in use. Areas clearly not wetted down. I understand the consent for this property notes that when the wind speed exceeds 5m/s (10knts) the applicant should water down and apply dust suppressant to unconsolidated areas, this has not occurred with wind speeds this afternoon averaging between 24knts - 28knts with gusts much higher than this and the quarry still operating. I also note that quarry operations should cease over 10m/s (20knts) this doesn't appear to have occurred.	2	Conservators Road, Yaldhurst
01/02/18	01/02/18	14:00	1/2/2018 Email received: Regarding Old West Coast Road. We have the predicted strong winds for today. According to Mote monitoring wind is over 10.8 m/s. Just been down the back and there is not water cart dampening down. Would like to know if Winstones and Winstones	2	Old West Coast Road, Yaldhurst

			Extension are using dust carts today. **2nd Email** 2/2/2018 11.20a.m. Email received 1/02/2018 8:13 p.m.: Put a complaint in earlier as strong winds (as predicted) and no water cart at Road Metals on Main West Coast Road. None either at Fulton Hogan. Still no water cart at either this evening and strong winds again.		
07/02/18	01/02/18	-	07/02/2018 8:00am - Email - Have you seen the video of the Fulton Hogan quarry up by the West Coast Road near Yaldhurst/Templeton doing the rounds showing Fulton Hogan failing to mitigate the dust from the quarry as required in their resource consent for the quarry? I would like to complain about this failure for them to meet such a basic condition of their consent. Hopefully the video captured 1st February 2018 is linked below showing the dust and the haze created by the quarry. I would appreciate feedback as to Ecan's actions in dealing with this violation on Fulton Hogan's part. I look forward to hearing from you soon. **FOLLOW UP REQUEST** 17/02/2018 7:29PM - EMAIL: "Hello I am looking to find out how the processing of my complaint surrounding the non-mitigation of dust at a Fulton Hogan quarry is going? I was informed that I would be contacted within 2 days and that was on the 7th of February. I would greatly appreciate some form of infomation and an expected process. Regards,".	1	West Coast Road near Yaldhurst, Christchurch
13 Feb 18	13 Feb 18	15:20	13/02/2018 3:20 pm Complaint about large quantities of dust coming out off SOL Quarries and particularly from trucks exiting the site. Noticed just now. The location is on Guys Road off Haul Road. Chch WM CWMS Zone CHCH CAZ. **2nd Call** 13/2/2018 4:19pm Caller reported dust coming from Sol quarries in Yaldhurst. The is a NW wind. Been happening all afternoon. Caller said they are breaching their consent conditions as they are speeding down the road and not wetting the area where dust is coming	2	Guys Road - Yaldhurst

			from.		
16 Feb 18	16 Feb 18	16:45	16/02/2018 4:49pm Caller reports large amounts of dust creating haze all along Mcleans Island Rd, Christchurch (no specific address). Caller stated that the dust is coming from all the quarries this area, including KBs quarry , Fulton Hogan quarry and Harewood quarry. Noticed just now (4:45pm). Currently a north west breeze.	1	Dust on McLeans Island Road, Christchurch

3.0 Conclusions

Six ambient air quality monitoring sites were operated for a period of one month 22 January 2018 – 21 February 2018. Three additional transect monitors were deployed to the south-east of the quarries from 9 February 2018.

Three exceedances of the hourly suggested trigger threshold for dust nuisance (150 µg/m^3, MfE 2016) were recorded at two monitoring locations on the same day (1 February 2018):

- Site 5 (South) 11 am (172 µg/m^3)and midday (204 µg/m^3)
- Site 3 (South) 12 pm (283 µg/m^3)

These exceedances coincided with a strong north-westerly wind change and dust complaints to Environment Canterbury.

There were no exceedances of the national environmental standard for PM_{10} recorded by the reference method monitors at Site 2 (North rural/residential) or Site 4 (Background rural/residential) during this period.

Co-located monitoring for PM_{10} using nephelometers and beta attenuation monitors (BAM) at two monitoring locations (Site 2 and Site 4) has provided good correlations between the methods. The data to date suggest the nephelometers are over-reading actual PM_{10} levels when compared with the reference method.

Co-located monitoring for $PM_{2.5}$ using nephelometers also appears to be providing robust, realistic ambient data.

4.0 References

MfE, 2009. *Good Practice Guide for Air Quality Monitoring and Data Management 2009*. Wellington. April. Available at www.mfe.govt.nz

MfE, 2016. *Good Practice Guide for Assessing and Managing Dust*. Wellington. November. Available at: www.mfe.govt.nz.